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Parker et al.

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[45] **Date of Patent: Jan. 4, 2000**

[54] **DECORATIVE OPTICAL DISPLAY APPARATUS**

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[73] Assignee: **Rainbow Design LLC**, Waitsfield, Vt.

[21] Appl. No.: **09/031,177**

[22] Filed: **Feb. 26, 1998**

Related U.S. Application Data

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[51] **Int. Cl.**[7] **G02B 5/18**; G02B 5/32; B42D 15/00

[52] **U.S. Cl.** **359/567**; 359/566; 359/15; 359/570; 359/1; 283/86; 362/806

[58] **Field of Search** 359/1, 2, 3, 24, 359/32, 15, 567, 570; 283/85, 86; 362/806–811

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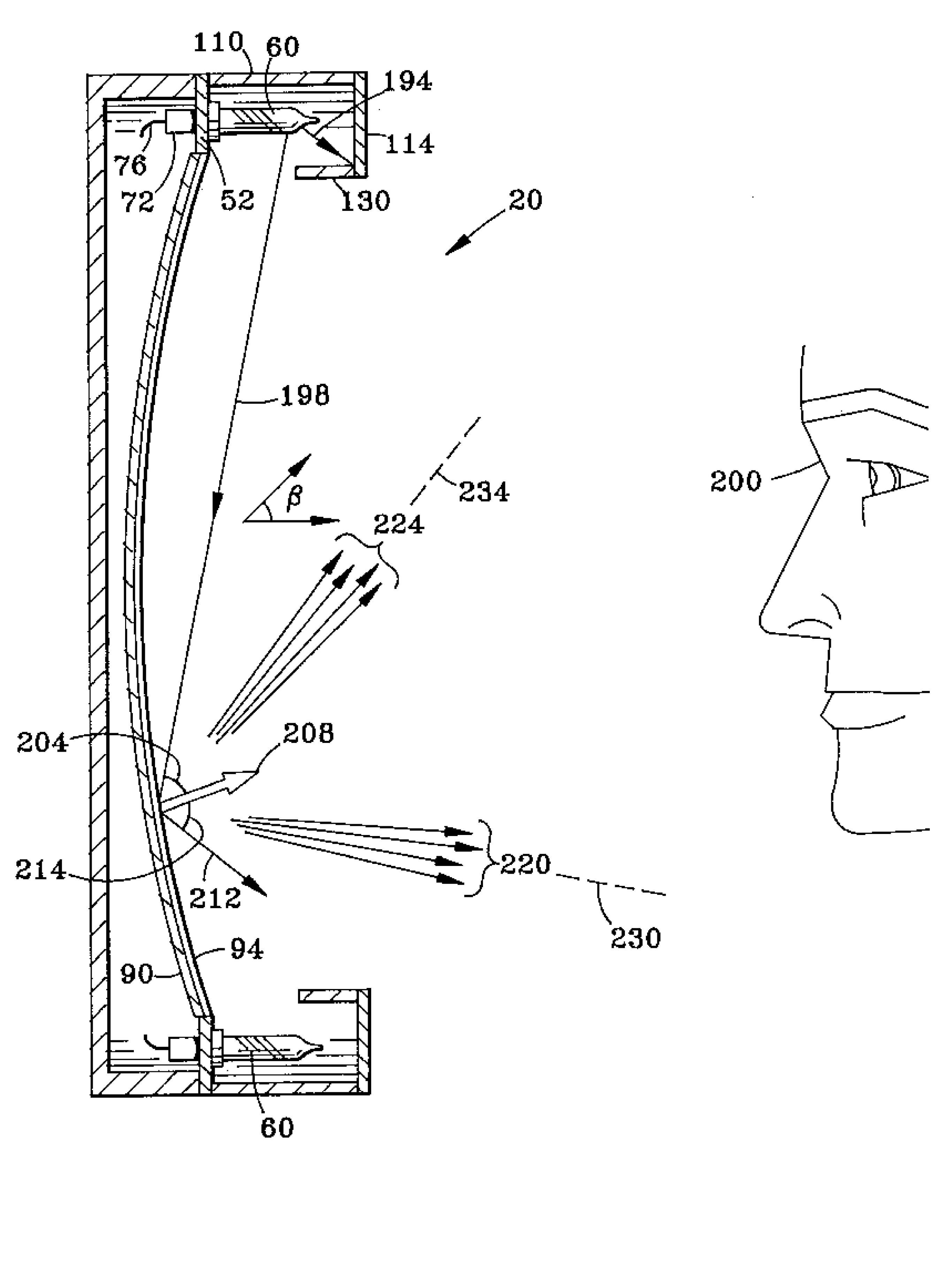
Attorney, Agent, or Firm—Downs Rachlin & Martin PLLC

[57] **ABSTRACT**

A decorative optical display (**20**) utilizing a reflective diffraction grating (**94**) or a transmissive diffraction grating (**304**) and a plurality of polychromatic light sources (**60**) disposed around perimeter (**106**) of the reflective diffraction grating or perimeter (**314**) of the transmissive diffraction grating. The light sources are disposed so as to the illuminate the reflective or transmissive diffraction grating at an oblique angle (**204**) or (**328**), respectively. The oblique illumination of the reflective or transmissive diffraction grating prevents a viewer (**200**) from seeing undiffracted light rays (**212**) or (**336**) emanating from the light sources, which can detract from the appeal of the optical display pattern (**250**). The reflective or transmissive diffraction grating may be flat or curved and may be supported by a support member (**90**). Further, the reflective or transmissive diffraction grating may have either a single or multiple axes. A shade (**114**) is provided to cover the light sources to prevent undiffracted light rays from reaching the viewer, or to hide wires (**76**) connecting the light sources. Also, the activation of the light sources is controlled via a control unit (**152**), and can be set to any one of a number of different temporal and spatial activation modes. The optical display is also adaptable for a variety of uses calling for an attractive display, such as a clock (**500**) or a display sign (**600**).

37 Claims, 8 Drawing Sheets



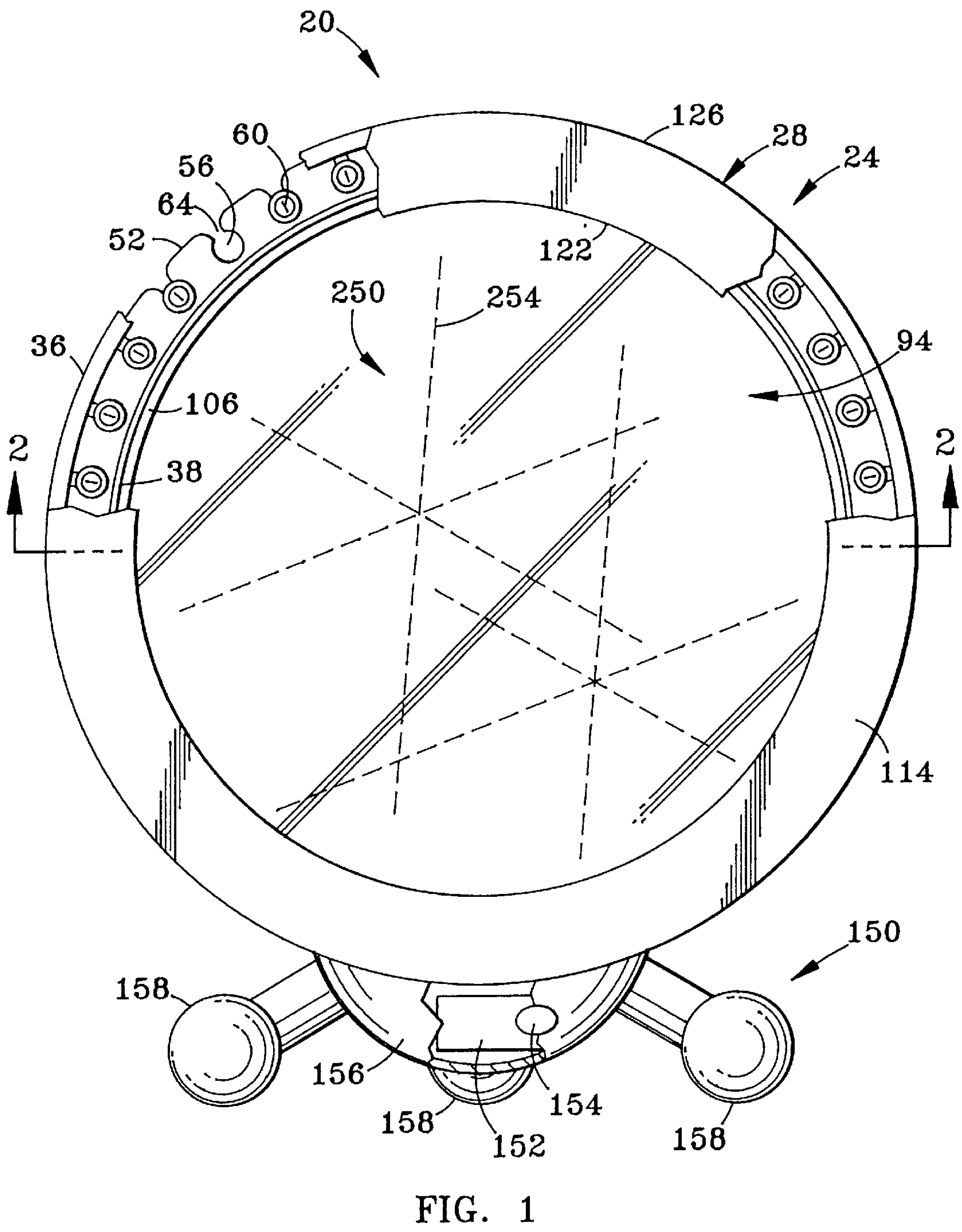

20
126
28
24
60
56
64
52
122
250
254
94
36
106
2
2
38
114
150
158
156
158
152
154
158

FIG. 1

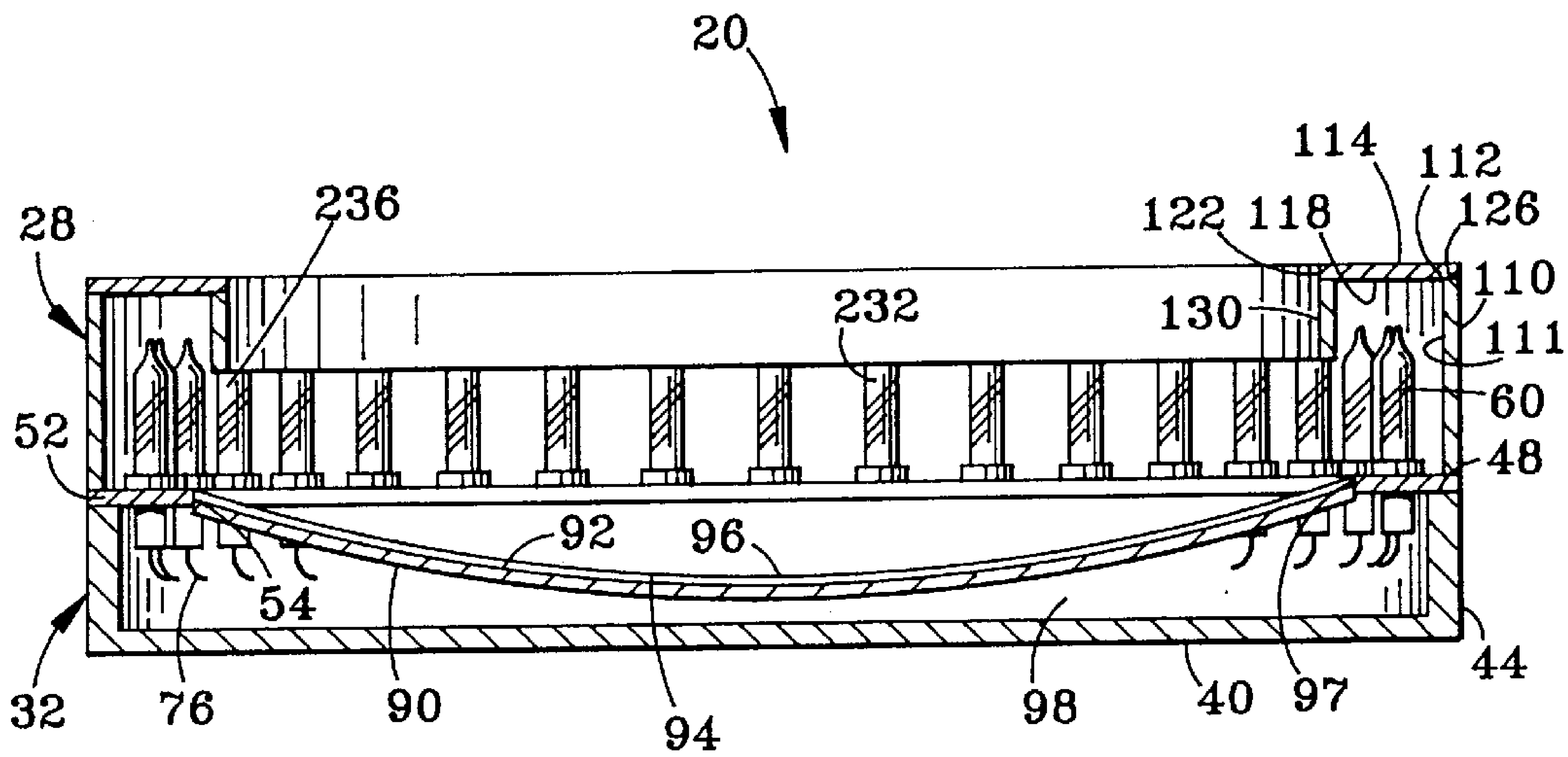


FIG. 2

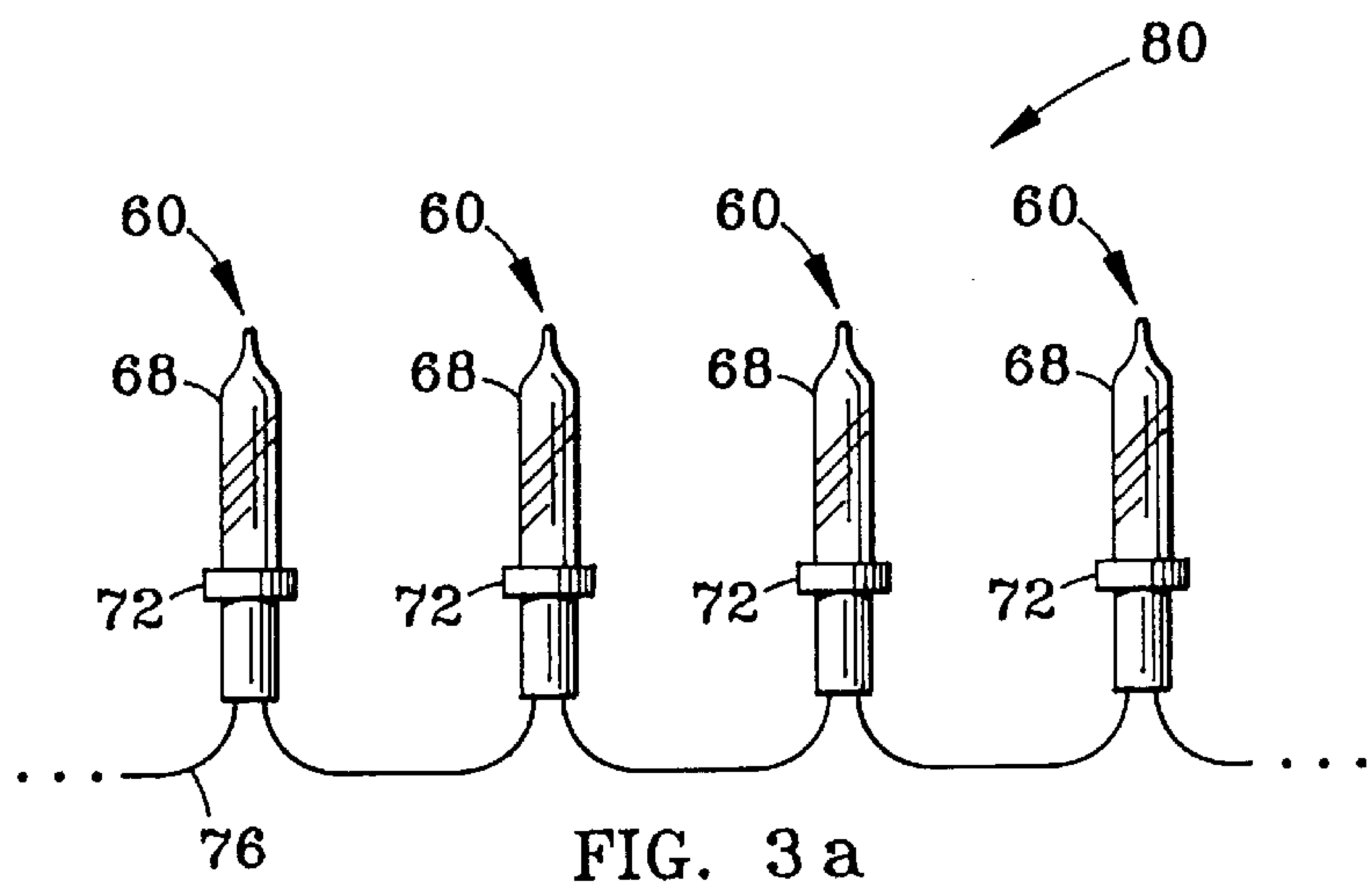
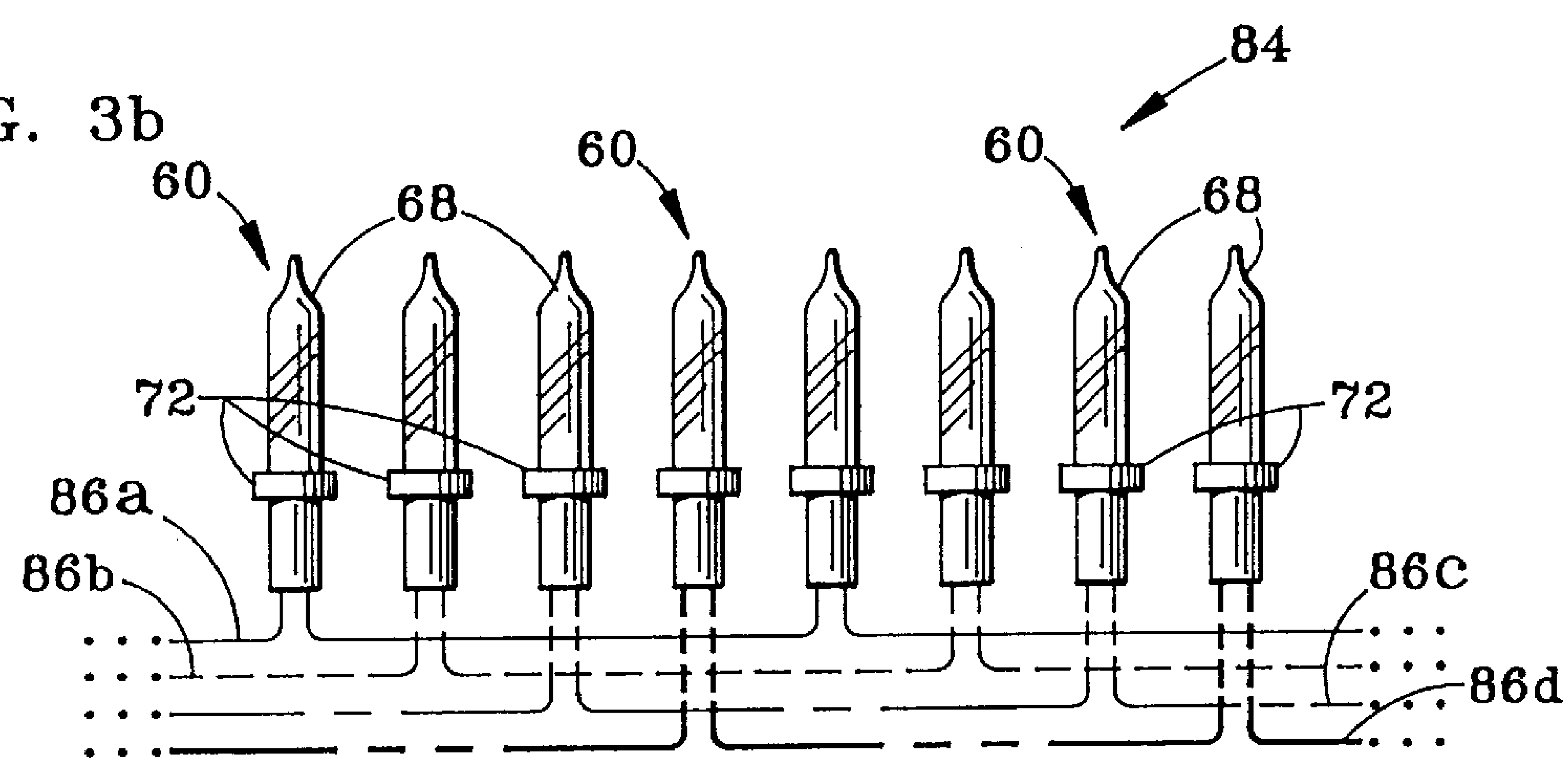


FIG. 3a

FIG. 3b



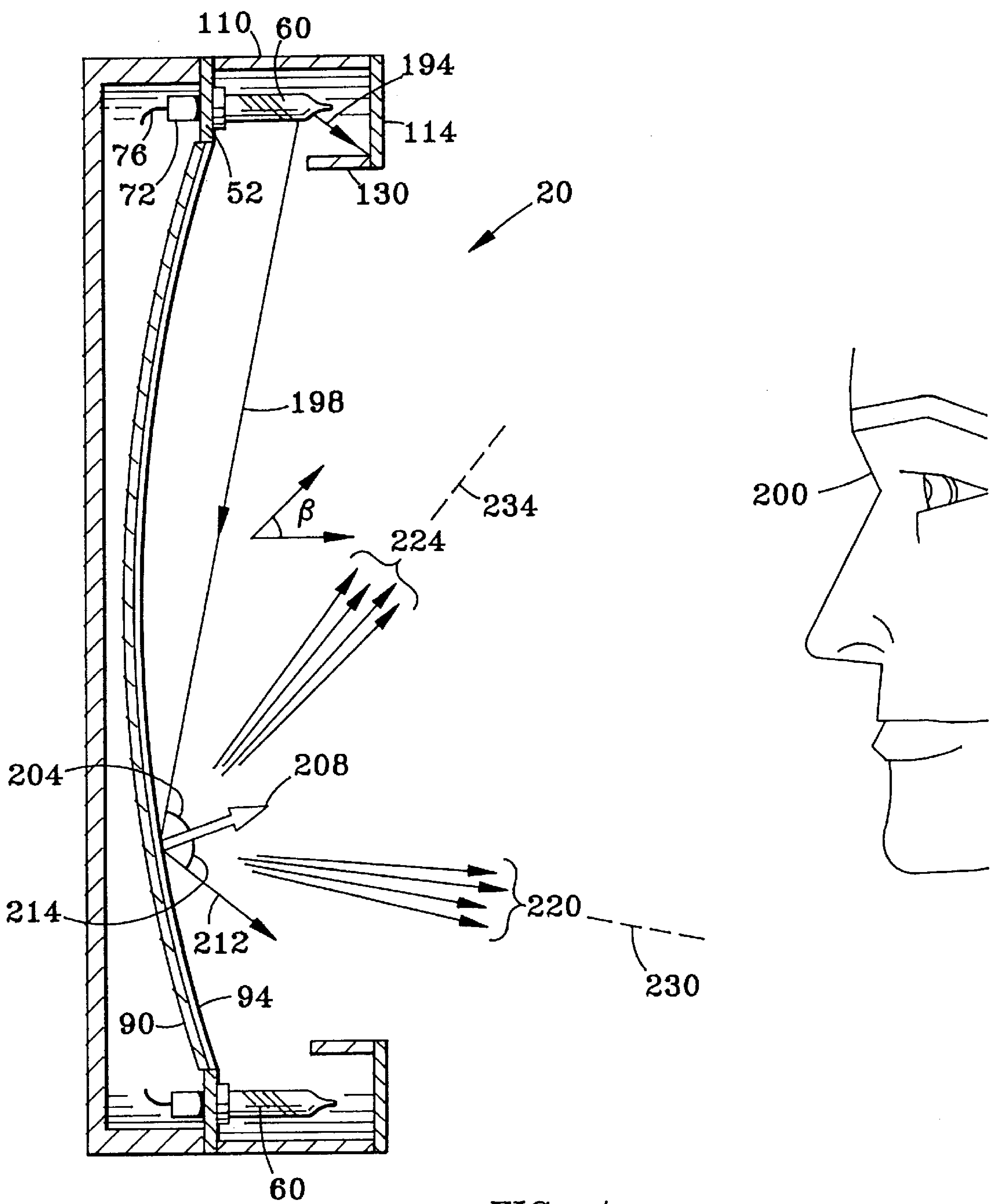

110
60
194
114
76
72
52
130
20
198
234
200
224
204
208
214
212
220
230
94
90
60

FIG. 4

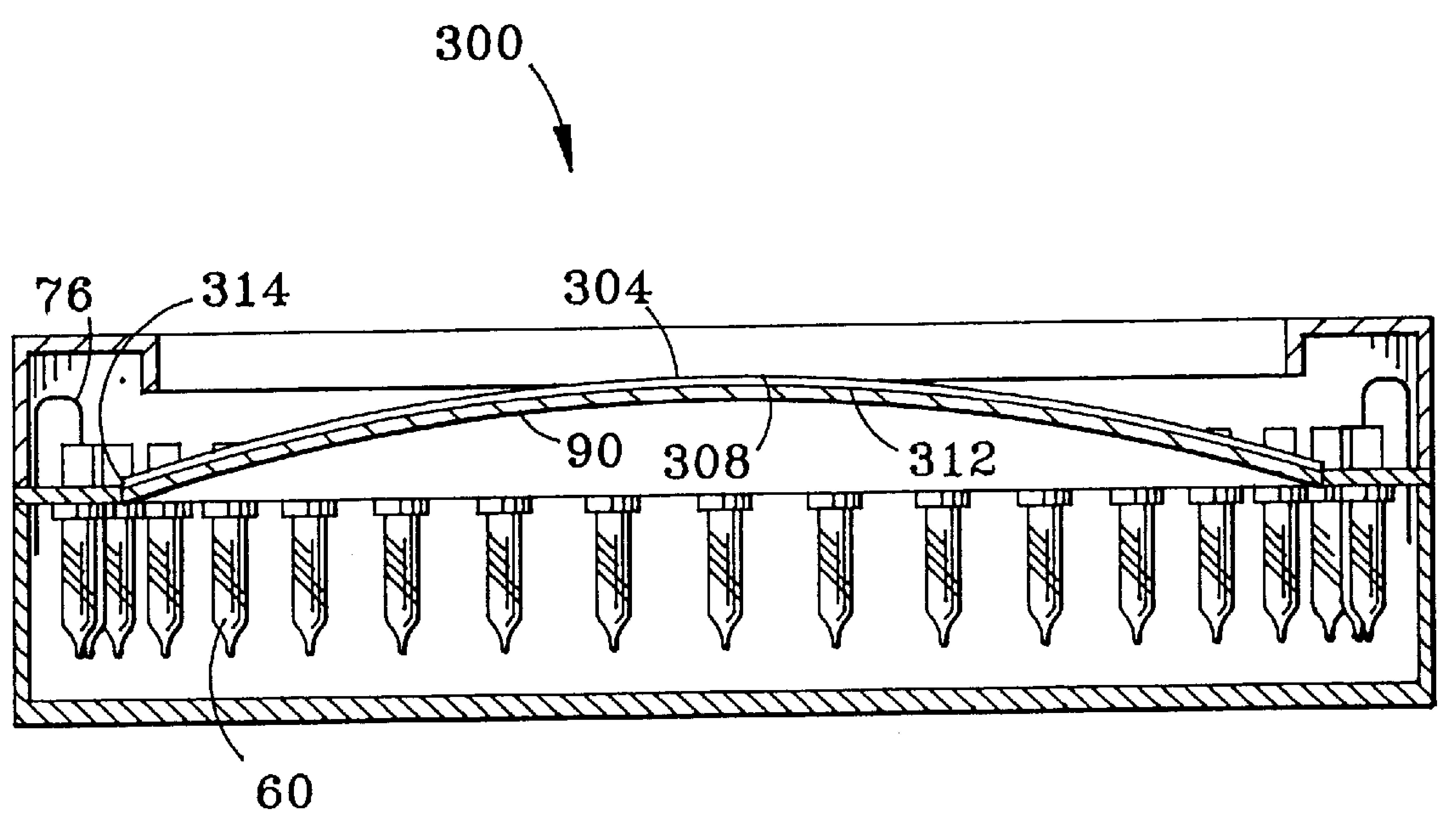


FIG. 5

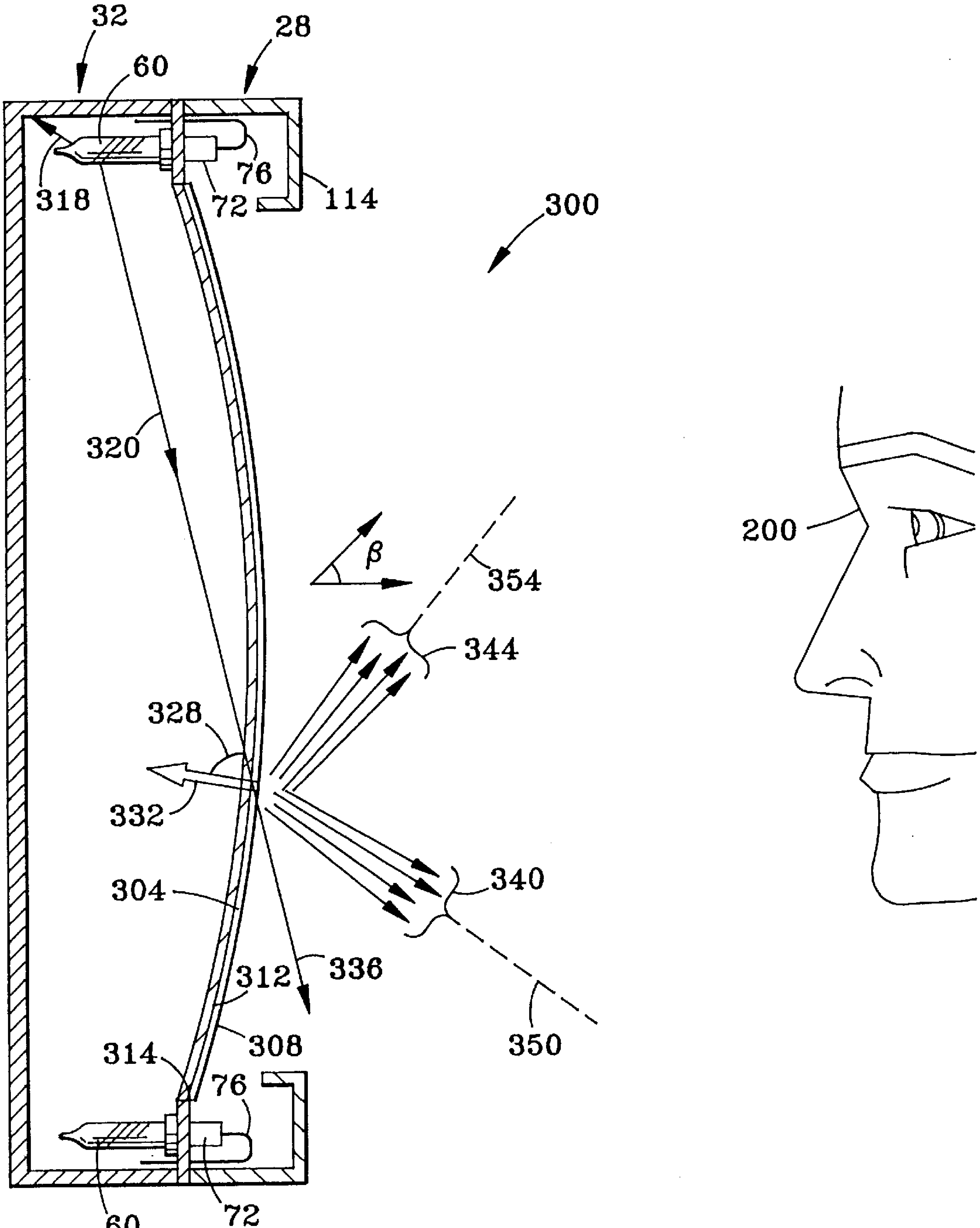

32
28
60
76
318
72
114
300
320
200
β
354
344
328
332
340
304
336
312
350
308
314
76
60
72

FIG. 6

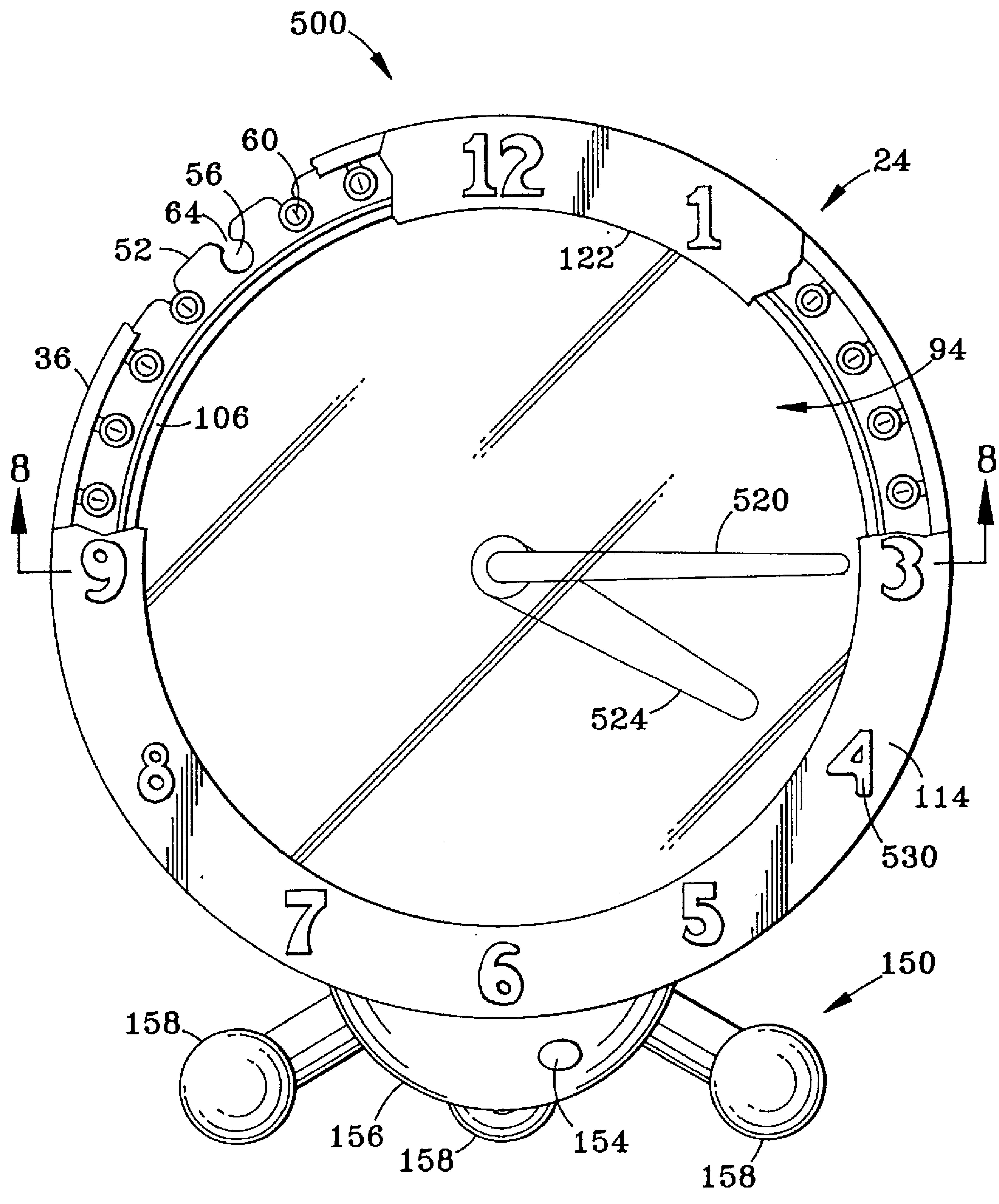

500
60
56
64
52
36
106
8
12
1
122
24
94
8
520
9
3
524
8
4
114
530
7
5
6
150
158
156
158
154
158

FIG. 7

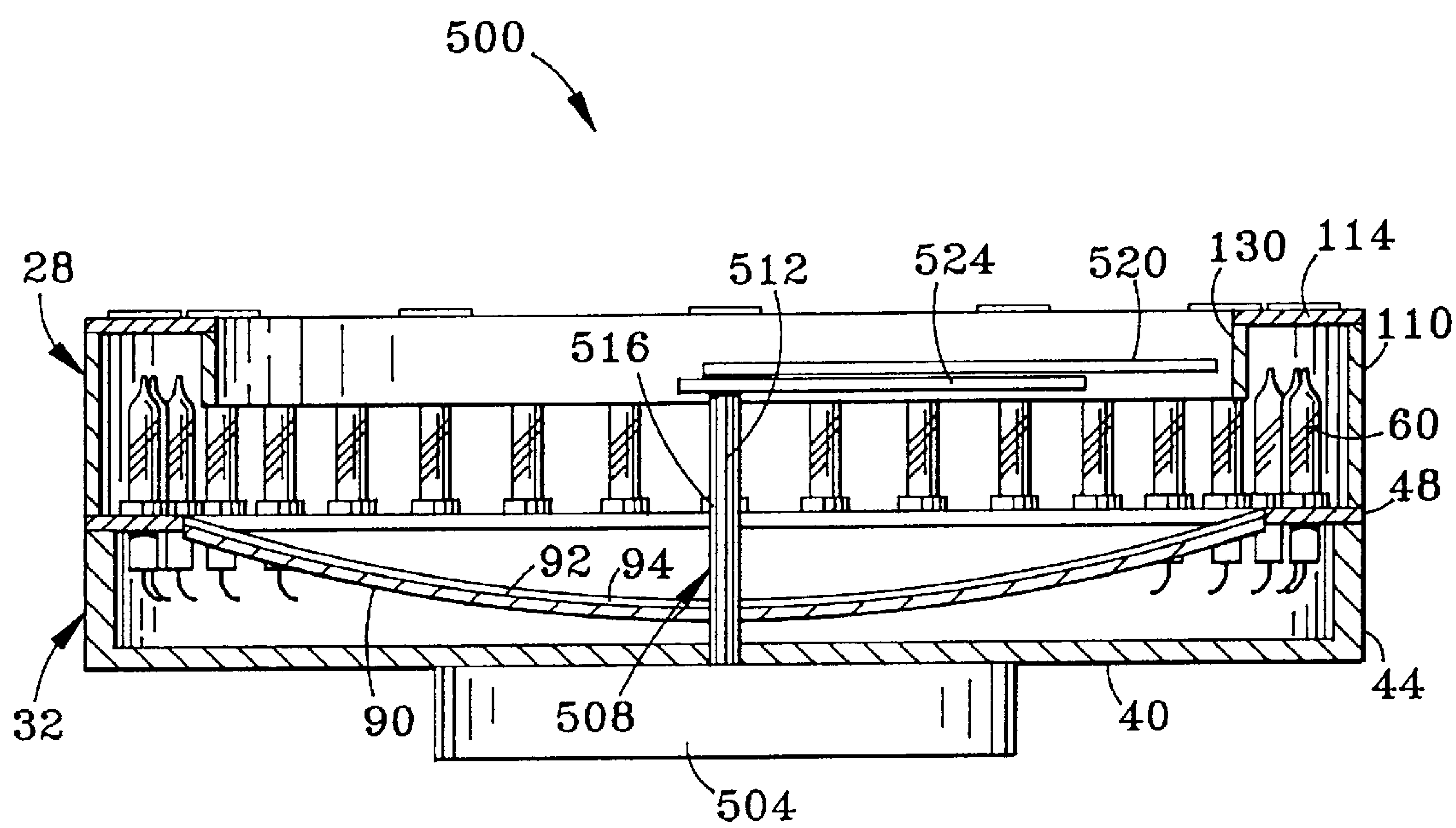


FIG. 8

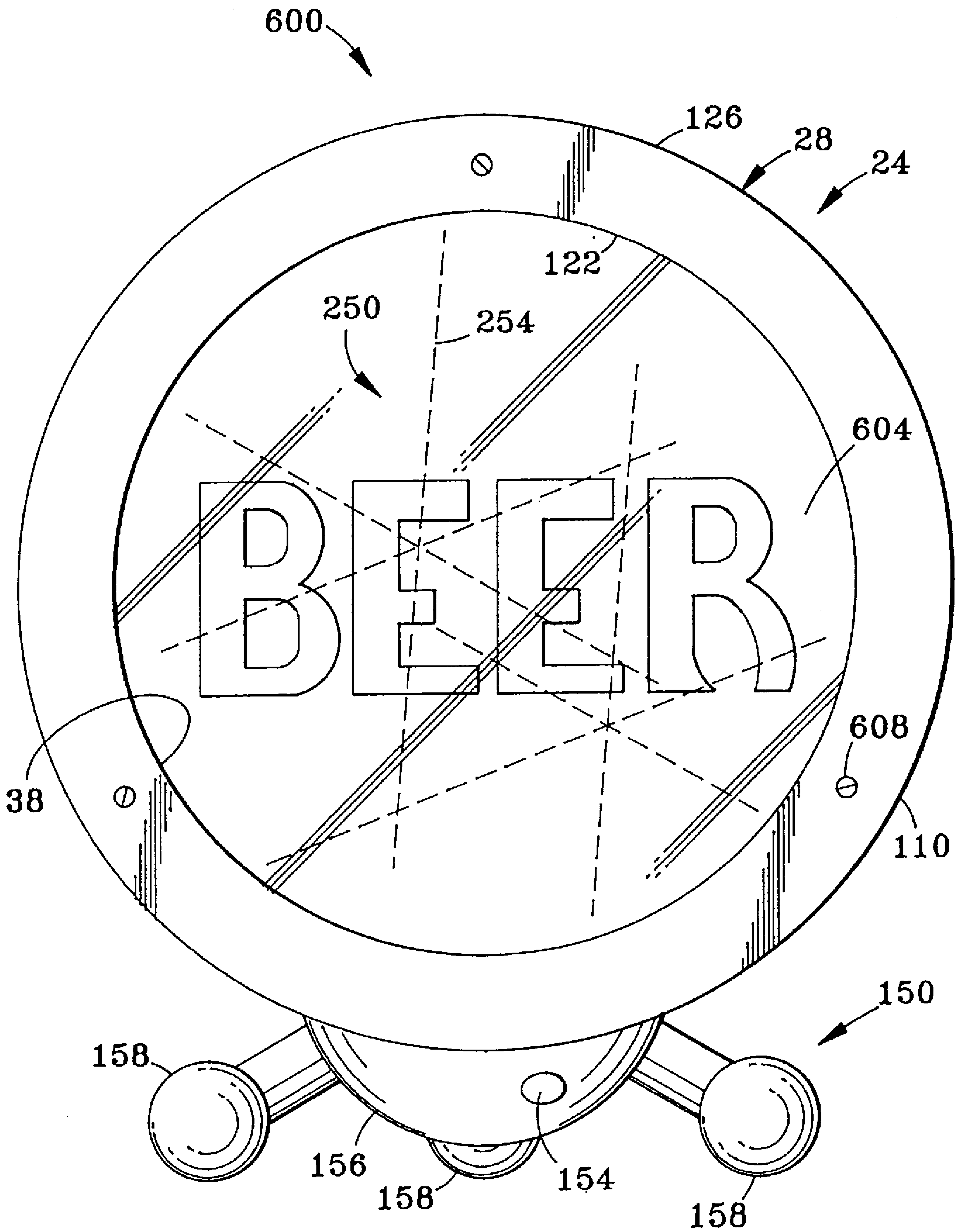

600
126
28
24
122
250
254
604
BEER
608
38
110
150
158
156
158
154
158

FIG. 9

DECORATIVE OPTICAL DISPLAY APPARATUS

This application claims the benefit of U.S. Provisional Application Ser. No. 60/042,189, filed Mar. 31, 1997.

FIELD OF THE INVENTION

The present invention relates to decorative optical displays, and in particular to such displays utilizing diffraction gratings to form a variety of decorative light patterns.

BACKGROUND OF THE INVENTION

Decorative optical displays have been popular as novelty items for over a century. Most of the known decorative optical displays (also referred to as "light sculptures," or "decorative lighting assemblies,") use various combinations of mirrors, light bulbs, lasers, prisms, lenses, colored glass, and diffraction gratings to achieve a variety of aesthetically pleasing visual effects.

A typical example of a decorative optical display apparatus is U.S. Pat. No. 5,276,599 to Neely, which discloses a light sculpture which displays light patterns inside a box-like enclosure. The enclosure includes planar mirrored panels joined together at right angles to form reflective walls, with one wall being translucent to permit an observer to look inside. Attached to the bottom of the enclosure is a hollow base which includes a plurality of light sources. The light patterns produced consist of light emanating directly from the light sources, as well as light reflected from the walls of the enclosure.

An example of an optical display apparatus that employs a diffraction grating is U.S. Pat. No. 734,133 to Porter (hereinafter, "the '133 patent"). The '133 patent discloses a light source, such as an arc lamp, placed behind a flat transmissive diffraction grating. The light source is then viewed through the diffraction grating by an observer. The diffraction grating disperses the light in a direction perpendicular to the orientation of the grating lines, so that an observer sees a "spoke" of light varying in color over its length. For a diffraction grating having multiple sets of grating lines (so called "multi-axis" diffraction gratings), multiple spokes of light are produced equal to the number of superimposed grating lines. Also, two separate diffraction gratings in proximity to one another can be used and motion can be imparted to the light patterns by rotating the diffraction gratings.

While the optical display of the '133 patent is capable of creating aesthetically pleasing light patterns, it also has several major drawbacks. The first is that placing one or more light sources directly behind the transmissive diffraction grating makes for a display apparatus that is non-compact. The second is that achieving motion in the light pattern by rotating the diffraction gratings makes the display apparatus complicated and expensive. The third is that it is not always desirable to view undiffracted light through the transmissive diffraction grating because the undiffracted light tends to overwhelm the diffracted light.

SUMMARY OF THE INVENTION

The present invention relates to decorative optical displays, and in particular to such displays utilizing diffraction gratings to form a variety of decorative light patterns. The decorative optical display includes a diffraction grating and a plurality of polychromatic light sources. The light sources are disposed about the perimeter of the grating such that they illuminate the grating at an oblique angle. The diffraction grating can be transmissive or reflective, and can have either a single diffraction axis, or multiple diffraction axes. Further, the diffraction grating need not be flat, but can be curved to enhance the optical display pattern. To maintain the shape of and otherwise support the diffraction grating, a support surface may be provided upon which the diffraction grating conformally resides. In the case of a reflective diffraction grating, the support surface can be opaque because the diffraction grating is illuminated from above. In the case of a transmissive diffraction grating, the support surface is reflective when illuminated from above, and non-opaque when illuminated from below. To create the effect of a dynamic display, a control unit is connected to the light sources for controlling various temporal and spatial activation modes of the light sources. A manual selecting means, such as a knob, is connected to the control unit and is used to select a particular temporal activation mode.

The optical display apparatus of the present invention is adaptable for a variety of uses calling for an attractive display. Thus, one such aspect of the present invention is an optical display clock. Another such aspect of the present invention is an optical display sign having a non-opaque faceplate over the front of the display and having letters or symbols inscribed or residing thereon.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front perspective view of the optical display apparatus of the present invention;

FIG. **2** is a cross-sectional view of an embodiment of the optical display apparatus of the present invention utilizing a reflective diffraction grating, taken at line **2—2** in FIG. **1**;

FIG. **3*a*** is a side view of a single-wire light string used in a preferred embodiment of the present invention;

FIG. **3*b*** is a side view of a multiple-wire light string used in a preferred embodiment of the present invention;

FIG. **4** is a schematic cross-sectional view similar to the view of FIG. **2**, illustrating the operation of the reflective diffraction grating embodiment of the present invention;

FIG. **5** is a cross-sectional view of an embodiment of the optical display apparatus of the present invention utilizing a transmissive diffraction grating, taken at line **2—2** in FIG. **1**;

FIG. **6** is a schematic cross-sectional view similar to the view of FIG. **5**, illustrating the operation of the transmissive diffraction grating embodiment of the optical display apparatus of the present invention;

FIG. **7** is a front perspective view of an optical display clock of the present invention;

FIG. **8** is a cross-sectional view of the optical display clock of FIG. **7**, taken at line **8—8**; and

FIG. **9** is a front perspective view of an optical display sign of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is an optical display apparatus for creating decorative light patterns using diffraction effects from either a reflective or a transmissive diffraction grating. Referring to FIGS. **1** and **2**, optical display apparatus **20** includes a main body **24** comprising a front housing **28** and a confronting rear housing **32** (see FIG. **2**). Front housing **28** is shown in FIG. **1** as having a display perimeter **36** and a large display aperture **38** that is circular, but display perimeter **36** and display aperture **38** can have an arbitrary shape.

Optical display apparatus **20** is properly viewed "face on," through display aperture **38**, as shown in the front view of FIG. **1**.

With reference to FIG. **2**, rear housing **32** includes a back **40** and a wall **44** with an upper rim **48**. Rear housing **32** further includes a light source mounting frame **52** fixed atop upper rim **48** of wall **44** and extending inwardly from wall **44**. Mounting frame **52** defines central aperture **38**. As can be seen in FIG. **1**, light source mounting frame **52** includes a plurality of light source mounting apertures **56** for mounting light sources **60**. Preferably, mounting apertures **56** include a slot **64** to facilitate the insertion and removal of light sources **60**.

With reference now to FIGS. **1** and **3***a*, in a preferred embodiment of the present invention, light sources **60** are polychromatic incandescent light bulbs having a glass enclosure **68** and a socket **72**, and are electrically interconnected by a wire **76** to form a single-wire light string **80**. Light string **80** is suitable when each light source **60** blinks independently and does not break the current flowing in wire **76**. Thus, light string **80** is preferred when simplicity is desired, since there is no need for a control unit to control the activation of light sources **60**, as described below. FIGS. **2**, **4**, **5**, **6** and **8** are shown to include a single-wire light string for the sake of simplicity.

With reference now to FIG. **3***b*, in another preferred embodiment of the present invention, a multiple-wire light string such as light string **84** is employed. Light string **84** includes light sources **60** alternately interconnected by wires **86***a*–**86***d*. Light string **84** is referred to as a "four-string" light string because it uses four different wires **86***a*–**86***d*. Wires **86***a*–**86***d* are arranged such that any set of four adjacent light sources in light string **84** are connected to a different wire. Also, every fifth bulb in light string **84** is connected to the same wire. Thus, counting the eight light sources **60** shown in FIG. **3***b* from left to right, wire **86***a* connects the first and fifth light sources, wire **86***b* connects the second and sixth light sources, wire **86***c* connects the third and seventh light sources, and wire **86***d* connects the fourth and eighth light sources. This pattern repeats over the length of light string **84**, which may have tens or hundreds of light sources **60**. An exemplary four string light bulb string for the present invention is sold by The East West Distributing Co., Deerfield, Ill., 600158, as model no. 889867.

When a multiple-wire light string such as light string **84** is employed, activation of the light sources is acheived by controlling the current flowing in each wire via a control unit, as is discussed further below. Light sources **60** in light string **80** or **84** are included in optical display apparatus **20** by sequentially inserting the light sources into respective mounting apertures **56** through slots **64**, whereupon socket **72** of each of the light sources is snap-fitted into the mounting aperture.

With reference now to FIG. **2**, rear housing **32** further includes a support member **90** having an upper surface **92**, and which, in a preferred embodiment, supports a reflective diffraction grating **94**. Support member **90** is connected to light source mounting frame **52** and spans substantially the entire length and width of rear housing **32**. That is, aperture **38** in mounting frame **52** is substantially entirely filled with support member **90**. Back **40**, wall **44** and support member **90** form a cavity **98** within which wires **76** from light sources **60** may be hidden. Support member **90** can be flat or have an arbitrary surface curvature, such as convex or concave. In a preferred embodiment, support member **90** is cylindrically concave (i.e., saddle-shaped), as is shown in FIG. **2**. Also in a preferred embodiment, back **40**, wall **44**, light source mounting frame **52** and support member **90**, comprising rear housing **32** are formed as a single injection-molded structure.

With reference to FIGS. **1** and **2**, reflective diffraction grating **94** has an upper surface **96**, a perimeter **97**, and in a preferred embodiment is thin and flexible so that it lies conformally on support member **90** so that upper surface **96** is opposite upper surface **92**. In a preferred embodiment, reflective diffraction grating **94** and support member **90** are made of dielectric materials (e.g., plastic and mylar, respectively) so that reflection diffraction grating **94** can be held in place on support member **90** by static electricity. In another preferred embodiment, reflective diffraction grating **94** may further include a framing member **106** running around perimeter **97**, which can be attached to light source mounting frame **52** (see FIG. **1**) or to support member **90** to hold the reflection diffraction grating in place relative to the support surface.

Reflective diffraction grating **94** may be a single-axis or multi-axis grating. In a preferred embodiment, reflective diffraction grating **94** is a two-axis grating having two sets of fine lines formed in surface **96** and oriented at right angles, each set of lines having a spatial frequency between 750–2000 lines/mm embossed in a 4 mil thick sheet of mylar having a reflective backing (e.g., aluminum). A reflection diffraction grating having a spatial frequency in the range between 750–2000 lines/mm is preferred because it provides for a strong diffraction effect (i.e., a high diffraction angle) at visible wavelengths. This allows for oblique illumination of the diffraction grating, the benefit of which in this reflective diffraction grating embodiment of the present invention is described in more detail below. Two exemplary diffraction gratings for the present invention are sold by SpectraTech Corp., 5405 Jandy Place, Los Angeles, Calif., 90060 under the trademarks SPECTRASHEEN (single-axis, 1000 lines/mm) and HOLOSHEEN (double-axis at right-angles, 1800 lines/mm).

With continued reference to FIGS. **1** and **2**, front housing **28** includes an outer wall **110** that is positioned on mounting frame **52** adjacent the periphery thereof. Outer wall **110** has an inner surface **111** and extends upwardly from mounting frame **52** and terminates at upper rim **112**. An annular shade **114** having an inner edge **122** is attached to outer wall **110** at upper rim **112** and extends inwardly so as to cover light sources **60** mounted in light source mounting frame **52**. In a preferred embodiment, shade **114** is opaque and prevents light from light sources **60** from being seen by a viewer viewing optical display apparatus **20**. Also in a preferred embodiment, display perimeter **36**, which defines the outer surface of outer wall **110**, is circular and shade **114** is annular, as shown in FIG. **1**.

With reference now to FIG. **2**, shade **114** preferably includes an inner wall **130** attached to shade **114** at its inner edge **122** so as to extend downwardly from the shade toward mounting frame **52**. Preferably, inner wall **130** terminates at a level at least equal with, if not slightly above, light sources **60**. Inner wall **130** serves to further hide light sources **60** from a viewer viewing optical display apparatus **20**, as is described further below.

With reference now to FIG. **1** and FIG. **3***b*, in the preferred embodiment where a multiple-wire light string such as light string **84** is used, optical display apparatus **20** further includes a control base **150** connected to main body **24**. Control base **150** includes a control unit **152** for controlling the operation of light sources **60** through wires **86***a*–**86***d* (not shown in FIG. **1**) which are fed into control base **150** and connected to control unit **152**. An exemplary control unit **152** for the present invention is sold by the previously mentioned East West Distributing Co., as unit E48723, catalog no. TY-11 (120V, 60Z, 0.8A). Control unit **152** controls the timing and sequence of current flowing in each of wires **86***a*–**86***d* to create a variety of light source activation sequences or "temporal and spatial activation modes" comprising the operating modes for optical display apparatus **20**.

Control base **150** also includes a manual setting device **154** connected to control unit **152** for manually setting the operating mode of optical display apparatus **20**. Manual setting device **154** may any one of a number of well-known setting means, such as a knob, a dial or pushbutton. Manual setting device **154** may also be in the form of a hand-held remote control unit (not shown) which communicates with the optical display control unit through a remote control sensor (not shown) incorporated into control base **150**. Also, in a preferred embodiment, control base **150** includes a control unit housing **156**, and support legs **158** for increased stability.

The operation of optical display apparatus **20** for creating an effective optical display is now described. Referring to FIG. **1**, a user activates light sources **60** by setting manual setting device **154** to the "on" position (not shown). At this point, the user may also choose from a number of settings associated with different temporal and spatial activation modes for light sources **60** to enhance the appeal of the optical display patterns. The different temporal and spatial activation modes may include, for instance, simultaneous activation of light sources **60**, random activation of light sources **60** and, more generally, alternate activation of various light sources **60** at various time intervals to create a wide variety of dynamic optical display patterns.

With reference now to FIG. **4**, each of light sources **60**, when activated, radiates polychromatic light rays, such as light rays **194** and **198**, over a wide range of directions. However, polychromatic light rays such as light ray **194** that would otherwise propagate toward a viewer **200** viewing optical display apparatus **20** are blocked by shade **114**. Other polychromatic light rays, such as light ray **198**, propagate toward reflective diffraction grating **94** and are incident on surface **96** at an incident angle **204** as measured with respect to reflective diffraction grating surface normal **208**. In general, the incident angles of polychromatic light rays from each of light sources **60** will vary depending on the position of the light sources **60** relative to surface **96** of reflective diffraction grating **94**. For instance, with reference to FIG. **2**, when support member **90** and reflective diffraction grating **94** are cylindrically curved, certain of light sources **60** (e.g., light source **236**) are closer to surface **96** than others (e.g., light source **232**). This variation in incident angle **204** for the different light sources **60** when reflective diffraction grating is cylindrically curved enhances the three-dimensionality of the optical display pattern.

A key aspect of the present invention is illuminating the particular diffraction grating at high angles of incidence so that light sources **60** can remain hidden from view and only diffracted light is seen by a viewer. Such illumination angles, which result in a viewer not being able to see undiffracted light from light sources **60**, are referred to herein as "oblique" angles. With continuing reference to FIG. **4**, in which optical display apparatus **20** utilizes reflection grating **94**, a portion of each incident polychromatic light ray **198** forms a reflected polychromatic light ray **212** having an reflection angle **214** equal to incident angle **204**. However, because of the relatively high incident angle **204**, reflection angle **214** is such that reflected polychromatic light ray **212** is outside the field-of-view angle β and thus not visible to viewer **200**. The remaining portion of incident polychromatic light ray **198** is diffracted within the field-of-view angle β into light ray spectrums **220** and **224** corresponding to first diffraction order **230** and second diffraction order **234**, respectively, and is visible to viewer **200**. In actuality, many diffraction orders may be present, but only two are shown for the sake of illustration.

An alternate equivalent embodiment of the present invention is replacing reflective diffraction grating **94** in optical display apparatus **20** with a transmissive diffraction grating (not shown) disposed conformally on or adjacent to support member **90** with upper surface **92** being reflective (see FIGS. **2** and **4**). The operation of this alternate embodiment is essentially the same as that described above for optical display apparatus **20**, and shown in FIG. **4**. A key difference, however, is that incident polychromatic light ray **198** passes through the transmissive diffraction grating twice, and is thus diffracted twice.

Another alternate embodiment of the present invention is an optical display apparatus utilizing a transmissive diffraction grating and an alternate illumination scheme. With reference to FIG. **5**, optical display apparatus **300** includes all the elements of apparatus **20** (see FIGS. **1** and **2**) except that reflective diffraction grating **94** in apparatus **20** is replaced with a transmissive diffraction grating **304** having a front surface **308**, a back surface **312**, and a perimeter **314**. Display apparatus **300**, in a preferred embodiment, appears the same as optical display apparatus **20** of FIG. **1**. However, certain of the elements comprising optical display apparatus **20** have a different disposition or are modified slightly in optical display apparatus **300**. For instance, light sources **60** are disposed "upside-down" in mounting apertures **56** of mounting frame **32** so that they point towards back **40** of rear housing **32**. Also, if a support member **90** is used to support a transmissive diffracting grating, it should be non-opaque. In addition, if support member **90** is to be curved, it should curve away from back **40** so that light sources **60** can illuminate back surface **312** of transmissive diffraction grating **304** at oblique angles. Also, shade **114** need not be used to prevent a viewer from seeing light sources **60** when viewing optical display apparatus **300**. However, it may be desirable to use shade **114** to cover wires **76** from being visible to a viewer viewing optical display apparatus **300**.

Further, transmissive diffraction grating **304** may be a single-axis or multi-axis grating. In a preferred embodiment, transmissive diffraction grating **304** is a two-axis grating having two sets of fine lines formed in either upper surface **308** or back surface **312**, and oriented at right angles. A transmission diffraction grating having a spatial frequency in the range between 750–2000 lines/mm is preferred because, as mentioned previously, it provides for a strong diffraction effect (i.e., a high diffraction angle) at visible wavelengths. This allows for oblique illumination, the benefit of which in the transmissive diffraction grating embodiment of the present invention is described in more detail below.

The operation of optical display apparatus **300** for creating an effective optical display is similar to that of apparatus **20**. For example, the activation step for optical display apparatus **300** is the same as for optical display apparatus **20**, described above with reference to FIG. **1**.

With reference now to FIG. **6**, each light source **60**, when activated, radiates polychromatic light rays over a wide range of directions. Certain of these light rays, such as light ray **318**, are not directed toward transmission diffraction grating **304** and are absorbed by the front housing **28** or rear housing **32**, the inner surfaces of which are preferably light-absorbing. Other light rays, such as light ray **320**, are incident on back surface **312** of transmission diffraction grating **304** at an oblique incident angle **328** as measured with respect to transmissive diffraction grating surface normal **332**. A portion of polychromatic light ray **320** is transmitted undiffracted through transmissive diffraction grating **304** as transmitted polychromatic light ray **336**. However, because of oblique incident angle **328**, light ray **336** is outside field-of-view angle β and thus not visible to viewer **200** viewing optical display apparatus **300**.

The remaining portion of incident polychromatic light ray **320** is diffracted within the field-of-view angle β into light ray spectrums **340** and **344** corresponding to first diffraction order **350** and **354**, respectively, and is visible to viewer **200**. In actuality, many diffraction orders may be present, but only two are shown for the sake of illustration.

Thus, with reference to FIGS. **1**, **4**, and **6**, viewer **200** viewing display apparatus **20** or **300** through central aperture **38** sees, within field-of-view angle β, an optical display pattern **250**. Field-of-view angle β, as used herein, is the limiting half-angle within which optical display pattern **250** consists of substantially only diffracted light rays, such as those in light ray spectrums **220** and **224** (FIG. **4**) and **340** and **344** (FIG. **6**). Accordingly, within field-of-view angle β (that is, within ±β), optical display pattern **250** (FIG. **1**) contains substantially no undiffracted light and consists substantially of one or more diffracted light curves **254** (shown as dashed lines in FIGS. **1** and **9**) that vary in color over their length and which appear suspended in space in three-dimensions behind either reflection diffraction grating **94** (see FIG. **4**) or transmissive diffraction grating **304** (see FIG. **6**). By choosing a particular temporal activation mode, optical display pattern **250** can be made very dynamic and have the effect of continuous or nearly continuous motion of diffracted light curves **254**, including the effect of rotation. The precise optical display pattern **250** seen by viewer **200** is a function of the curvature of support member **90** and curvature of either reflective diffraction grating **94** or transmissive diffraction grating **304** lying conformally thereon or otherwise connected thereto, the spatial frequency, orientation and number of grating lines contained in the particular diffraction grating, and the spectral composition and temporal activation mode of light sources **60**. In a preferred embodiment, field-of-view angle β is 60 degrees.

It will be apparent to one skilled in the art that various means for illuminating diffraction gratings **94** or **304** at oblique angles (see FIGS. **4** and **6**) are possible for providing a wide field-of-view angle β. For instance, a single light source can be used when inner surface **111** (FIG. **2**) of outer wall **110** is reflective. Or, a single-ring light source having mutually spaced opaque segmentations can be used. In addition, a single light source can be used with mirrors positioned around mounting frame **52** (see, e.g., FIG. **2**) to deflect light toward the surface of diffraction grating **94**.

The optical display apparatuses **20** and **300** of the present invention are also adaptable for a variety of uses calling for an attractive display. For example, with reference to FIGS. **7** and **8**, there is shown an optical display clock **500** comprising all the elements of optical display **20** as described above, and further including a clock motor **504** attached to back **40** of rear housing **32**. Clock motor **504** includes a double drive shaft **508** having an inner shaft **512** and an outer shaft **516**. Drive shaft **508** protrudes through apertures formed in back **40**, support member **90** and reflective diffraction grating **94**, respectively. Minute hand **520** is attached to inner shaft **512** and hour hand **524** is attached to outer shaft **516**. Preferably, double drive shaft **508** extends to a height approximately equal to the level of inner wall **130** of shade **114** so that minute hand **520** and hour hand **524** do not cast a shadow on reflective diffraction grating **94** when light sources **60** are activated.

With continued reference to FIGS. **7** and **8**, in a preferred embodiment, shade **114** includes a transparent or semi-transparent symbols, such as numbers **530**, formed therein. Light from light sources **60** blacklight numbers **530** so that they are readily visible to a viewer.

Another adaptation of display apparatuses **20** or **300** is for an attractive display sign. For example, with reference to FIG. **9**, there is shown an optical display sign **600** comprising optical display apparatus **20** as shown in FIG. **1** and further including a non-opaque faceplate **604**. Faceplate **604** is attached, for example, to shade **114** by screws **608** and covers display aperture **38**. Faceplate **604** may also be attached to inner wall **130** of shade **114** by screws or any number of well-known securing means, such as screws, tape, pre-formed, slots, and the like. Faceplate **604** includes opaque or semi-transparent lettering, symbols, or words, such as the word "BEER," as shown in FIG. **9**.

Since certain changes may be made in the optical display apparatuses disclosed herein with respect to preferred embodiments without departing from the scope of the present invention, it is intended that all matter contained in the above description or shown in the accompanying drawings be interpreted in an illustrative and not in a limiting sense.

What is claimed is:

1. A decorative optical display comprising:

a) a diffraction grating having an isotropic grating pattern and having a perimeter and a surface; and

b) a plurality of light sources disposed adjacent said perimeter such that each light source substantially entirely illuminates said diffraction grating surface over a wide range of oblique angles so as to form a display pattern comprising diffracted light curves.

2. A decorative optical display according to claim **1**, wherein said diffraction grating is a multiple-axis grating.

3. A decorative optical display according to claim **1**, wherein said diffraction grating is reflective.

4. A decorative optical display according to claim **1**, wherein said diffraction grating is transmissive.

5. A decorative optical display according to claim **1**, further including a shade disposed adjacent said plurality of light sources so as to prevent undiffracted light from reaching a viewer viewing the display.

6. A decorative optical display according to claim **5**, wherein said shade is opaque.

7. A decorative optical display according to claim **6**, wherein said shade is annular.

8. A decorative optical display according to claim **7**, wherein said diffraction grating perimeter is circular.

9. A decorative optical display according to claim **1**, wherein said plurality of light sources are evenly spaced around said perimeter.

10. A decorative optical display according to claim **1**, wherein said light sources in said plurality of light sources are electrically interconnected.

11. A decorative display according to claim **1**, wherein said plurality of light sources are polychromatic.

12. A decorative optical display according to claim **1**, wherein said diffraction grating perimeter is circular.

13. A decorative optical display according to claim **1**, wherein said diffraction grating has a spatial frequency between 750 and 2000 lines/mm.

14. A decorative optical display according to claim **1**, wherein said diffraction grating is curved.

15. A decorative optical display according to claim **1**, further including a support member to support said diffraction grating.

16. A decorative optical display according to claim **15**, wherein said curve is cylindrical concave.

17. A decorative optical display according to claim **15**, wherein said support member is non-opaque and said diffraction grating is transmissive.

18. A decorative optical display according to claim **15**, wherein said support member has a reflective upper surface and said diffraction grating is transmissive.

19. A decorative optical display according to claim **15**, wherein said diffraction grating lies conformally on said support member.

20. A decorative optical display according to claim **19**, wherein said support member is curved.

21. A decorative display according to claim **1**, further comprising a control unit connected to said plurality of light sources for causing said plurality of light sources to operate in one or more temporal and spatial activation modes.

22. A decorative optical display according to claim **21**, wherein said control unit includes a manual selection means for manually selecting said one or more temporal and spatial activation modes.

23. A decorative optical display according to claim **22**, wherein one of said one or more temporal and spatial activation modes includes a random illumination sequence.

24. A decorative optical display clock, comprising the decorative optical display of claim **1** and further including:

a) an aperture through said diffraction grating;

b) a clock motor with a drive shaft, said clock motor disposed adjacent said diffraction grating, with said drive shaft extending through said aperture; and

c) at least one clock hand attached to said drive shaft.

25. A decorative display clock according to claim **24**, further including a shade with numbers formed therein.

26. A decorative display clock according to claim **25**, wherein said numbers are translucent.

27. A decorative display sign comprising the decorative optical display of claim **1**, and further including a faceplate disposed above said diffraction grating surface, said faceplate being non-opaque and having symbols thereon.

28. A decorative optical display having a field-of-view angle β, comprising:

a) a diffraction grating having an isotropic grating pattern and have a perimeter and a surface; and

b) a plurality of light sources disposed adjacent said perimeter in a manner such that each light source substantially entirely illuminates said diffraction grating surface over a wide range of oblique angles so as to form a display pattern comprising a plurality of diffracted light curves wherein substantially all light emanating from the optical display falls within said field-of-view angle β.

29. A decorative optical display according to claim **28**, wherein said field-of-view angle β is equal to or less than 60 degrees.

30. A decorative optical display according to claim **28**, wherein said diffraction grating is transmissive.

31. A decorative optical display according to claim **28**, wherein said diffraction grating is reflective.

32. A decorative optical display according to claim **28**, wherein said diffraction grating perimeter is circular.

33. A decorative optical display according to claim **28**, wherein said diffraction grating is supported in a curved geometry.

34. A decorative optical display according to claim **28**, further including a control unit electrically connected to said illumination means for causing said illumination means to operate in one or more temporal and spatial activation modes.

35. A decorative optical display according to claim **34**, further including a manual selecting means connected to said control unit for manually selecting said one or more temporal and spatial activation modes of said illumination means.

36. A decorative optical display comprising:

a) a diffraction grating having an isotropic grating pattern and having a perimeter and a surface, with no particular display pattern recorded therein; and

b) a plurality of light sources disposed adjacent said perimeter such that each light source substantially entirely illuminates said diffraction grating surface over a wide range of oblique angles so as to form a display pattern comprising diffracted light curves.

37. A decorative optical display having a field-of-view angle β, comprising:

a) a diffraction grating having an isotropic grating pattern and have a perimeter and a surface, with no particular display pattern recorded therein; and

b) a plurality of light sources disposed adjacent said perimeter in a manner such that each light source substantially entirely illuminates said diffraction grating surface over a wide range of oblique angles so as to form a display pattern comprising a plurality of diffracted light curves wherein substantially all light emanating from the optical display falls within said field-of-view angle β.

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